PRELIMINARY NOTES ON MANTIGUE ISLAND CAPTURE FISHERIES: IMPLICATIONS OF A MARINE RESERVE

Aileen P. Maypa, Angel C. Alcala and Gary R. Russ

ABSTRACT

Marine reserves are often advocated as tools for sustainable fishery management. However, evaluation techniques on the effectiveness of established reserves are few. Although the Before-After-Control-Impact Pair (BACIP) experimental designs are most appropriate in detecting marine reserve impacts, they are rarely used. This study reports the first part of the BACIP results for Mantigue Island fishery yield. Based on daily roving creel surveys total estimated yield of the reef/seagrass fishery for 2000 was 4.88 t/km²/yr. Reef associated fish yield is 0.82 t/km²/yr and non-reef is 5.76 t/km²/yr. Of the 42 fish families caught, Belonidae (42%), Scaridae (10.3%), Engraulidae (7.6%), Labridae (7.28%) and Caesionidae (4.77%) dominated the annual catch. Four fishing gears were used in Mantigue: gill net, spear gun, hook and line and fish pots. Highest estimated total annual catch was also from gill nets, yielding 8.11 t of fish. Reef-associated fish catch per unit effort was significantly higher compared to reef/seagrass and non-reef catches but catch was lower than non-reef. Low reef/seagrass fish yield and data on fish lengths of some species caught suggest that the reef/seagrass fisheries of Mantigue Island may have reached growth overfishing. If unsustainable fishing practices are continued, further degradation of fishery resources may move up to the higher levels of overfishing. Immediate management action is therefore essential. Establishment of a marine reserve in the area is now being undertaken through community based management. With BACIP used as the experimental design, the impacts of the Mantigue I. marine reserve on its fishery will be readily quantified over time.

Introduction

High population growth, fishery overexploitation, and lack of skills and tools for resource management have resulted in the decline and collapse of marine fisheries in many areas (FAO 1995, Vitousek et al. 1997, Fogarty and Murawski 1998, Lauck et al. 1998). Marine reserves, defined as areas protected from all forms of fishing and extractive activities (Bohnsack 1998), have been advocated worldwide as a tool for sustainable fishery management (e.g. Alcala and Russ 1990, 1996a, Allison et al 1998, Lauck et al. 1998, Done and Reichelt 1998, Murray et al. 1999, Maypa 2002). Evidence is accumulating that higher diversity and abundance, and larger sizes of fish and other organisms are direct effects of protection (Alcala and Russ 1990, Russ and Alcala 1996a, 1996b, 1998, Edgar and Barrett 1999, Epstein et al.1999, Johnson et al. 1999, McClanahan and Mangi 2000). Moreover, the maintainance of high reef and reef associated fish yields, in the order of 15-30 t/km^2/yr over 20 years in Apo I. suggests the effectiveness of marine reserves as a tool for fishery rehabilitation and enhancement (Alcala and Luchavez 1981, White and Savina 1987, Bellwood 1988, Maypa et al. 2002). However, in order to quantify the effectiveness of a marine reserve, the condition of the resources of a selected area must be evaluated. Often, Rapid Resource Assessments are the only source of baseline information and it is very seldom that fishery catch is studied in detail.

Some of the most detailed documented reef fish yields in the Philippines are from small coral islands. From Apo Island, total reef /reef associated yields range from 16.69 to 31.8 t/km^2/yr (Maypa et al 2002), Sumilon: 14 to 36.9 t/km^2/yr (Alcala 1981, Alcala and Russ 1990), Selinog: 6 to 18 t/km^2/yr (Alcala and Gomez 1985, Cruz, unpubl. data), Pamilacan: 17.9 t/km^2/yr, including gleaning (Savina and White 1986), San Salvador: 7 to 14 t/km^2/yr (Christie and White 1994). These studies provide valuable information for experimental designs such as Before-After Control-Impact-Pair (BACIP). Yet, although such designs are most appropriate for detecting impacts of marine reserves, they are rarely used (Russ 2002). This study is the first part of the BACIP experimental design for Mantigue Island. We report the fish yield, seasonal changes in catch, catch per unit effort (CPUE) of different fish groups, and volume of catch of the different fishing gears used around Mantigue Island for the year 2000 prior to the formal protection of its marine reserve.

Materials and methods

Study site

This report was based on fish catch data from Mantigue Island (9°10.3'N, 124°49.5' E; Fig. 1) from January to December 2000. Mantigue is a 0.07 km^2 island. Located 3.7 km southeast of Camiguin Island in the Mindanao Sea, it is under the jurisdiction of the municipality of Mahinog. A 0.45 km^2 multispecies seagrass bed and a 0.55 km^2 fringing reef surround the island. Mantigue has a population of approximately 178 individuals, a majority of whom depend on fishing and shell collecting as a primary source of income.

A marine reserve, 0.037 km^2 in area, was established on August 21, 2000 through the efforts of Silliman University-Angelo King Center for Research and Environmental Management, the Camiguin Polytechnic State College, the province of Camiguin, the local government of Mahinog, and Mantigue Island fisherfolk. Efforts to protect started immediately after establishment, though illegal fishers were still reported. Total protection was achieved in January 2001.

Fish yield and catch per unit effort (CPUE) estimation

Fish yield and CPUE estimates were computed from data gathered daily through roving creel surveys from January to December 2000. Recorded fish catches were reported by fishers to have been caught within the 80m isobath. Data were collected by a researcher and a fish enumerator trained in fish identification using local fish names. CPUE data collection included interviewing of fishers on fishing hours and fishing grounds daily, per landing. Landed fish were weighed to the nearest 10 grams using commercial fish weighing scales. Mantigue Island fishing gears included: (a) gill nets, (b) hook and line, (c) spear guns, and (d) fish pots. Fish yield for reef/seagrass species was calculated using the combined coral reef and seagrass areas of 1.0 km^2, and for reef associated species, the 0.55 km^2 coral reef area was used. Samples for genus or species level identification were collected. Identifications were based on Masuda et al. (1984), Randall (1997), Smith and Heemstra (1986), and Fish Base 2000 (Froese and Pauly 2000). Major fish groupings followed Bellwood (1988) and Choat and Bellwood (1991).

Fish catch during the main fishing seasons in Mantigue Island was compared using weekly replicates consisting of weights of fish caught daily. This analysis was limited to the 10 major fish families which comprised 86% of the catch for the year 2000. Weekly replicates for each season were n=27 for the northeast monsoon (NE; November to early April), n=16 for the southwest monsoon (SW; June to September), and n=6 for the calm interim period (INT; October, late April to May). A Two-Way ANOVA was used in comparing differences between families during fishing seasons, and for finding significant differences in CPUE between fish groups. A Bonferroni Post Hoc Test revealed where the significance lay. All data were tested for normality and homoscedasticity using Kolmogorov's Test and Levene's Test, respectively (Velleman 1997). A Box-Cox transformation was applied to non-normal or heteroscedastic data.

Fish Length

Caesio caerulaurea was chosen for detailed study since it is a reef species and its local name is specific to the species, therefore minimizing identification mistakes. It is also harvested throughout the year in Mantigue I. Further, caesionids are known for their resiliency in fishing, though they decline rapidly in abundance when fished heavily (Russ and Alcala 1998). These characteristics therefore serve as good indicators of the current fishing intensity and pressures in the area. Fork lengths (FL) of individual *Caesio caerulaurea* were derived from weights of individual fish using the formula in Fish Base 2000 (Froese and

Pauly 2000): W=a.L^b (where: W=weight, a=constant, L=FL, b=constant). No significant difference was seen in fish sizes between seasons (ANOVA, p=0.7529), thus, mean FL of *C. caerulaurea* was computed by combining all derived FL data from NE, SW monsoons and INT periods (n=163). *Caesio caerulaurea* FL from Mantigue was then compared with *C. caerulaurea* FL from Apo Island (n= 185) for the year 2000. The fishery yield of Apo I. is known to be fairly large (Maypa et al 2002). Apo I. is also situated in the Mindanao Sea with a well managed reserve protected for almost 20 years (Russ and Alcala 1999). This well documented fishery provided a good point of reference and comparison for fish length studies in Mantigue I.

Results

Fish yield, catch composition, seasonality and length

Forty four families in approximately 65 genera comprised the fish caught from Mantigue Island in the year 2000. Of these families, 42 were finfish and two were mollusks (Table 1). Estimated non-reef fish yield was 5.76 t/yr, seagrass/reef fish yield was 4.88 t/km^2/yr and that of reef associated fish 0.82 t/km^2/yr. In spite of the diversity of families caught, Belonidae (42.12%), Scaridae (10.3%) Engraulidae (7.6%), Labridae (7.28%) and Caesionidae (4.77%) dominated. Mantigue I. residents rely mainly on non-reef fish as their source of food and income. Belonids, *Tylosurus* spp., are caught all year round using gill nets and hook and line. The volumes of belonids caught during NE (110.5±14.71 kg/wk) and SW (139.3±19.09 kg/wk, respectively; Fig. 2) was significantly higher than that of other families caught in all seasons (ANOVA, $p \leq 0.0001$, Table 2). In addition, Engraulids (INT: 17.59± 4.89 kg/wk) and Clupeids (INT: 14.8±33.14 kg/wk) also contributed to the bulk of the non-reef catch. Among the dominant reef/seagrass fish species were scarids (INT: 27.25±4.54 kg/wk), labrids (INT: 24.89±5.54 kg/wk) and caesionids (INT:18.75±4.14 kg/wk).

The majority of the reef/seagrass fish species caught were small which can be readily attributed to the mesh sizes of the gill nets commonly used ($\leq$5 cm; A. Maypa, pers. obs.). The average length (FL) of sampled *Caesio caerulaurea* from Mantigue was significantly smaller (18.42±0.17 cm) than those measured from Apo Island (24.94±0.16 cm; T-test, $p<0.0001$). This species reaches up to 35 cm (TL), based on Randall et al. (1997). Furthermore, scarids such as *Scarus ghobban*, with a total length of 20 cm was considered large by Mantigue I. residents. This species reaches 75 cm (Randall et al. 1997).

Gear types and catch rates

Gill net catch on a per trip basis (annual mean catch= 8.33±0.39 kg/trip) was significantly higher compared to the catch using other gears in all seasons (Fig.3, Table 2). In contrast, fish pot catch during the northeast monsoon was significantly lower ($p<0.0001$) compared to the catch using the rest of the gears in various seasons (hook and line $_{SW/NE/INT}$: 3.63±0.29 kg/trip, spear gun, $_{SW/NE/INT}$: 2.99±0.15 kg/trip, fish pot $_{SW\&INT}$: 2.21±0.12 kg/trip, fish pot $_{NE}$: 1.19±0.21 kg/trip). Highest estimated total annual catch was from gill nets, yielding 8.11 t; 76% of the total fish caught in 2000 (Table 3).

Catch per unit effort (CPUE) of major fish groups

The catch per unit effort for different fish groups on a per gear basis is shown in Figure 4. No significant differences were found between gears (Table 2). However, significant differences existed between fish groups (Table 2). Reef associated catch, although comprising only 4.09% of the total annual yield, had a significantly higher CPUE than those among coastal and non-reef species (Table 2).

Discussion

The total estimated annual yield of fish from Mantigue I. was dominated throughout the year by belonids and other non-reef species. Among the reef fishes, labrids and scarids made up most of the bulk of the annual catch. Reef associated catch provided the smallest contribution to the total catch, but had the highest CPUE among major fish groups (Fig. 4). Gill net catch contributed 76% of the total annual yield while hook and line, spear gun and fish pot catch made up the rest of the 24%.

Reefs worldwide such as those in Jamaica and the Philippines are rapidly approaching or have reached Malthusian overfishing, i.e., fishers resort to resource destruction due to a large population of fishermen with declining catch (Russ 1991). In the South Jamaican Shelf, fishing effort over a span of 15 years increased with no corresponding increase in catch (Koslow et al. 1988). In Mantigue I., fishers reported dynamite fishing practiced in the late 1970s to early 1980s. Previously blasted coral reefs around the island show little recovery today. Sand/rubble areas are still evident.

These data suggest that Mantigue Island's reef/seagrass fishery resources are overfished. Residents are currently dependent on non-reef fish species, particularly belonids which comprised almost half of the annual catch in the year 2000. The island's estimated total annual yield of coastal fisheries is very low compared to other nearby islands in the Mindanao Sea. In Mantigue, only 4.38 $t/km^2/yr$ of coastal fish are caught even though fisherfolks fish all year round, unlike other areas in the Philippines (e.g., Apo Island) where fishing activities are limited by strong winds and rough waves generated by the NE monsoon. From November to April, Apo Island's major fishing ground is hit by the northeast monsoon, drastically reducing fishery. However, fish yields in Apo range from almost 16.69 to 31 $t/km^2/yr$ of reef and reef-associated species. (Maypa et al. 2002). Sumilon Island has yielded more than 30 $t/km^2/yr$ of reef fish, dominated by caesionids (Alcala and Russ 1990, Russ and Alcala 1998). Both Sumilon and Apo Islands have protected marine reserves since 1974 and 1982, respectively (Russ and Alcala 1999).

Our results suggest that Mantigue island has reached the condition of growth overfishing. This is defined as the point where there is a substantial reduction in the proportion of large size classes of fish caught (Russ 1991). Although the catch per unit effort of different gears and of various fish groups caught in Mantigue is comparable to other islands in the Mindanao Sea (Alcala and Luchavez, 1981, White and Savina 1987, Alcala and Russ 1990, Maypa et al 2002), sizes of fish caught are smaller. *Caesio caerularea* caught from Mantigue reefs had an average size of 18.42±0.17 cm (FL) and comparatively smaller than *C. caerulaurea* from Apo Island (24.94±0.16) and reported maximum sizes (to 35 cm, TL; Randall et al. 1997, Froese and Pauly 1996, Kuiter and Debelius 1997). However, Russ and Alcala (1998) documented that when fished intensively the abundance of caesioinids also declines rapidly. Small sizes of *C. caerulaurea* in areas known to be fished intensively may therefore indicate potential overfishing. Further evidence of potential growth overfishing in Mantigue I. comes from observed lengths of other fish species. Scarids of 20 cm in total length, such as *Scarus ghobban* (maximum TL=75 cm; Randall et al.1990) are considered large by Mantigue I. residents. It was also observed that 90% of the *Plectorinchus* spp. sampled from the catch were only 10 to 15 cm. *Plectorinchus lineatus* reaches a TL of 60 cm (Kuiter and Debelius 1997). Gill nets, especially three-ply nets (mesh sizes: 5 to 1 cm) are very popular in the area. These catch all fish sizes, including juveniles. Continued fishing using small mesh sizes will reduce and deplete both density and biomass of fish populations. This may lead to impairment of larva production and subsequent recruitments, a condition otherwise known as recruitment overfishing (Russ 1991). Immediate action is therefore essential to prevent further degradation of Mantigue's coastal resources. The establishment of a 0.037 km^2 reserve is expected to improve the condition of the coastal fishery resources of the island through protection of fish habitat and spawners, education, and changes in fishing policies.

A growing body of evidence supports that long-term protection of marine reserves results in higher diversity and abundance, and larger sizes of fish and other organisms (e.g., Alcala and Russ 1990, Russ and Alcala 1996a, 1996b, 1998, Edgar and Barrett 1999, Epstein et al. 1999, Johnson et al. 1999, McClanahan and Mangi 2000). Further, evidence on adult fish biomass export and enhancement of fish stocks from the reserve to adjacent fishing grounds (spillover) is also accumulating. Russ and Alcala (1996a, b) documented an exponential increase in biomass of large predatory fish inside Apo I. marine reserve over time. In addition, they also documented the decrease of large predatory fish biomass as distance from the reserve increased. McClanahan and Mangi (2000) also found that fish catch per trap, mean size of trapped fish and diversity of fish species caught per trap declined with increasing distance from the reserve. Long term high reef and reef associated fish yields have also been documented in fishing grounds adjacent to Apo I. marine reserve (Maypa et al. 2002).

Although some Mantigue residents are still opposed to the concept of a marine reserve, support for the project is growing. With continued technical support from the academe, local government, and the influence of fishing communities with successful marine reserves, changes toward sustainable practices and marine reserve protection commitment are expected to improve the coastal fishery resources of Mantigue I. in the near future. When monitored individually through time, catch per unit effort of coral reef species time will be a good indicator of the effectiveness of the marine reserve. However, the continued use of gill nets as the major fishing gear in Mantigue poses some limitation. Consequently, a detailed study on fish lengths of the demersal fishery is recommended. Monitoring of the biomass and density of reef-associated species over time in conjuction with CPUE may provide some insights into the role of this fish group on marine reserve spillover issues.

Acknowledgments

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Table 1. Total sample yield (TSY) and per cent contribution (%TY) of all fish families caught in Mantigue I., Camiguin southern Philippines from January to December 2000.

Family	%TV	TSY(kg)	Genera/Family
Reef/Seagrass	**43.99**		
Acanthuridae	3.68	391.60	*Acanthurus, Ctenochaetus, Naso*
Apogonidae	0.02	2.36	*Apogon*
Atherinidae	0.02	2.5	*Hypoatherina*
Balistidae	0.22	23.44	*Balistoides, Melichthys*
Bothidae	0.01	1.2	*Pardachirus pavoninus*
Caesionidae	4.77	508.44	*Caesio*
Chaetodontidae	0.04	4.34	*Chaetodon*
Dasyatididae	1.51	160.55	*Dasyastis*
Diodontidae	0.67	71	*Diodon*
Epipphidae	0.11	11.8	*Platax*
Fistulariidae	0.04	4.85	*Fistularia*
Gereidae	0.25	26.72	*Gerres*
Haemulidae	0.06	6.3	*Plectorhinchus*
Holocentridae	0.19	20.34	*Myripristis, Sargocentron*
Kyphosidae	0.87	93.5	*Kyphosus*

Labridae	7.28	775.82	*Cheilinus, Cheilo, Halichoeres, Stethojulis, Thalassoma*
Lethrinidae	0.76	81.1	*Lethrinus*
Lutjanidae	0.06	6.93	*Lutjanus, Aprion*
Monocanthidae	0.02	2.7	*Aluterus*
Mugilidae	0.05	5.35	*Liza/Mugil*
Mullidae	1.90	200.52	*Mulloidichthys, Parupeneus*
Muraenidae	1.22	130.05	*Gymnothorax*
Nemipteridae	0.41	43.37	*Scolopsis*
Ostraciidae	0.02	2.65	*Ostracion*
Plotosidae	0.13	14.05	*Plotosus*
Pomacentridae	1.86	207.07	*Amblyglyphidodon, Amphiprion, Chromis, others*
Scaridae	10.3	1097.27	*Scarus*
Scorpaenidae	0.13	13.60	*Synanceia*
Serranidae	0.08	9.20	*Epinephelus, Cephaloholis*
Siganidae	1.40	148.9	*Siganus*
Synodontidae	0.35	37.55	*Synodus*
Tetraodontidae	0.12	12.5	*Arothron*
Terapontidae	0.02	1.85	*Terapon*
Loligonidae (Mullusca)	2.00	212.52	*Sepia, Sepioteuthis*
Octopidae (Mullusca)	0.92	97.55	*Octopus*

Table 1. (Continued)

Yield (t/km2/yr)		4.88	
Reef associated	4.09		
Carangidae	4.13	440	*Decapterus,Carangoides, Caranx, Elagatis*
Sphyraenidae	0.13	14.05	*Sphyraena*
Total		454.05	
Yield (t/km2/yr)		0.82	
Non-reef species	51.92		
Belonidae	42.12	4478.95	*Tylosurus*
Clupeidae	2.49	261.25	*Herklotsichthys*
Elopidae	0.09	9.25	*Elops*
Engraulidae	7.60	808.85	*Stolephorus*
Exocoetidae	0.07	7.20	*Cypselurus*
Hemiramphidae	0.16	16.75	*Hemiramphus*
Scombridae	0.96	102.25	*Grammatorcynus, Ruvettus, Scomberoides, Thunnus*
Lutjanidae	0.76	80.40	*Aphareus*
Total		5764.9	
Yield (t/yr)		5.76	

Table 2. Results of Two-Factor Analysis of Variance (μ=0.05). Only significant post hoc results are presented. SW=Southwest monsoon, NE=Northeast monsoon, INT=Interim period, bel=Belonidae, eng=Engraulidae, g=gill net, h=hook and line, s=spear gun, p=fish pot, all others= all families in Fig. 2, RA=reef associated, CF=coastal fish, NR=non-reef.

Factor tested	Test (ANOVA)		Bonferonni *post hoc* (significance)
Yield/family	F	*P*	
Season	4.6055	p< 0.0105	SW >NE; p=0.00
family	47.114	p< 0.0001	bel > all other
season*family	3.3881	p< 0.0001	SWbel=NEbel >INTbel ;p =0.0046 =SWeng = all others
Catch/gear			
season	0.36948	p= 0.6911	Not significant
gear	45.502	p< 0.0001	g>h; p=0.0000, g>p; p=0.0000
season*gear	1.4262	p= 0.2007	Not significant
CPUE/fish group			
fish group	548.75	p< 0.0001	RA>NR; p=0.0026, RA>CF; p=0.0017
gear	12.294	p= 0.6698	Not significant
Fish group*gear	1.8446	p= 0.1371	Not significant

Table 3. Total annual catch, per cent contribution and overall catch per unit effort (CPUE, mean±SE) of different fishing gears used in Mantigue Island, southern Philippines in 2000. ND=no data.

Gear	% Total catch	Total catch (kg)	Annual CPUE (kg/man-h)
Gill net	76.21	8,114.91	1.1±0.04
Hook & line	9.04	962.64	1.61±0.08
Spear gun	13.08	1,392.55	1.15±0.05
Fish pot	1.67	178.34	ND
Total (sample)	100	10,648.44	

Figure 1. Map of Mantigue I., Camiguin, southern Philippines.

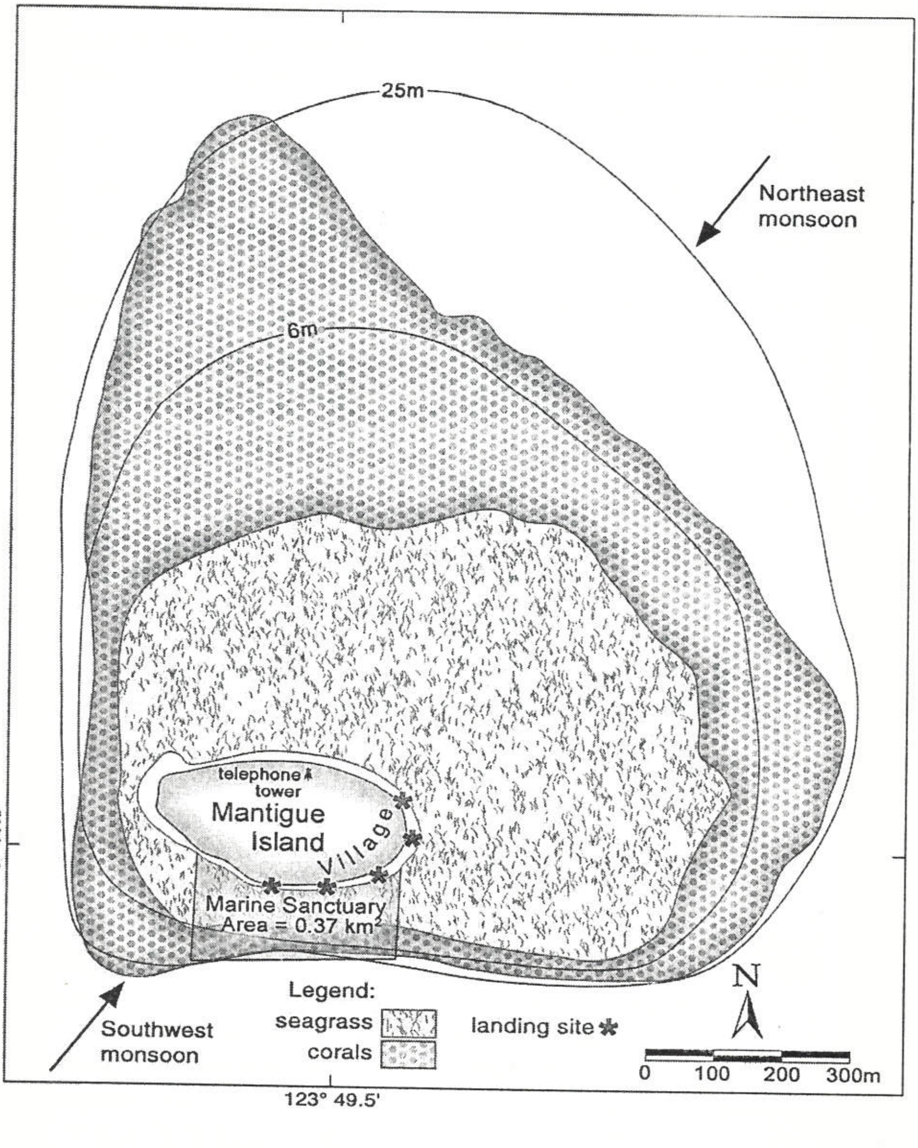


Figure 2. Seasonal patterns in the mean weekly yields (mean?SE) of major fish families comprising 86% of the total annual yield in the year 2000, from Mantigue , Camiguin, southern Philippines (NE=northeast monsoon, SW=southwest monsoon, INT=interim period).

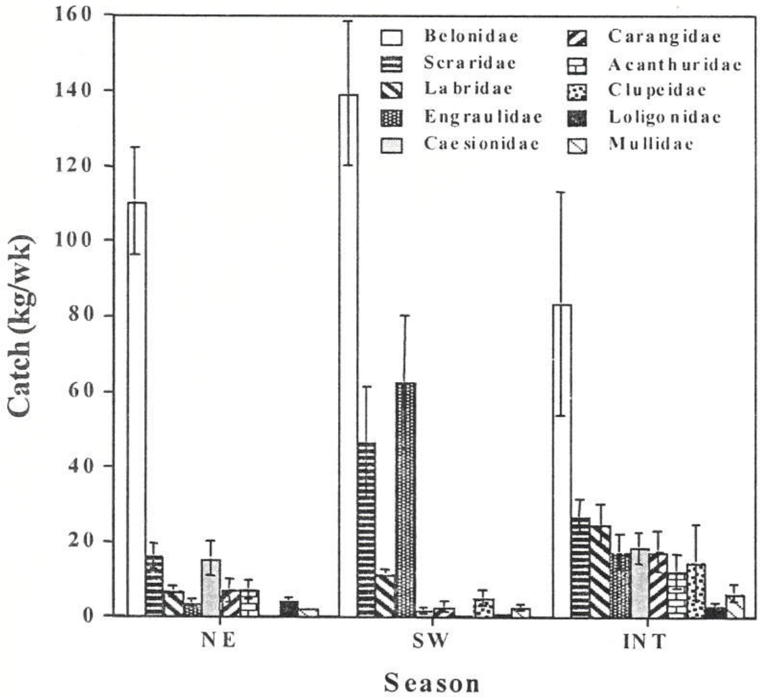


Figure 3. Seasonal patterns in gear catches per trip (mean?SE) in the year 2000 from Mantigue I., Camiguin, southern Philippines (NE=northeast monsoon, SW=southwest monsoon, INT=interim period).

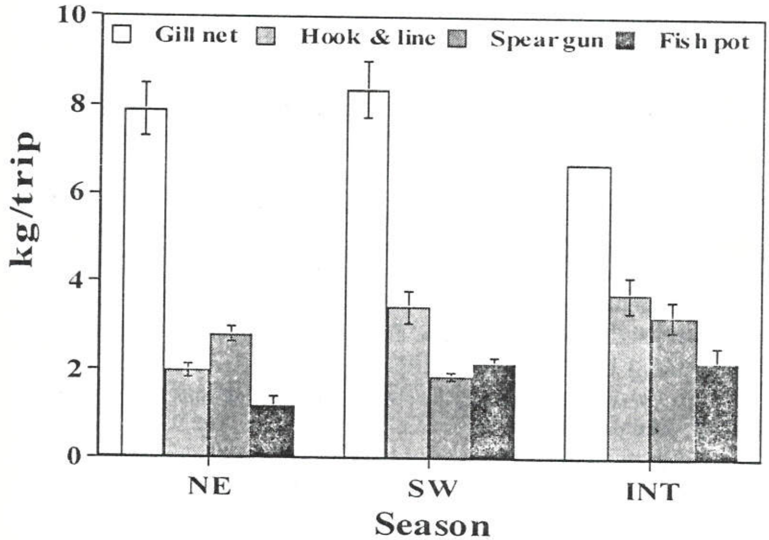
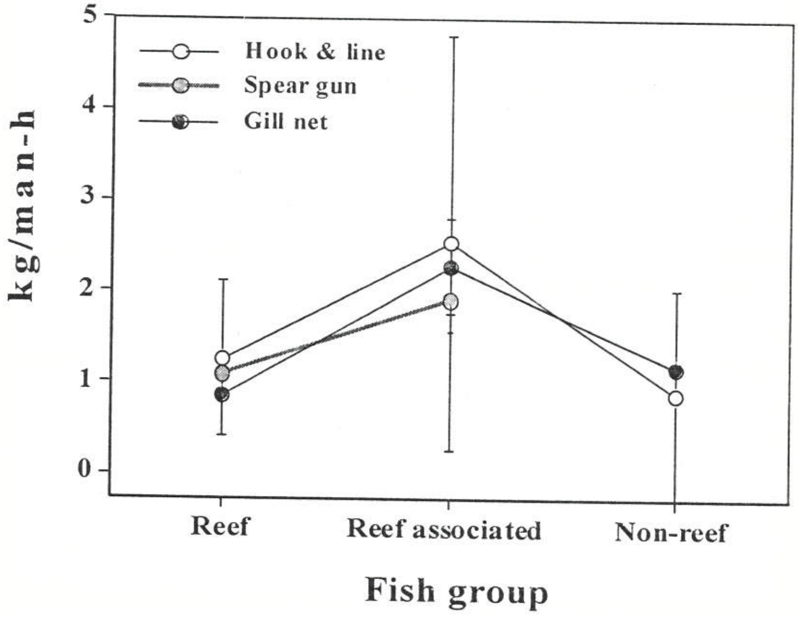


Figure 4. Trends in catch per unit efforts (mean?SE) of different fish groups caught by different geartypes in the year 2000 from Mantigue I., Camiguin, southern Philippines.



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